II. "Observations of Temperature during two Eclipses of the Sun (in 1858 and 1867)." By JOHN PHILLIPS, M.A., LL.D., D.C.L., F.R.S., Professor of Geology in the University of Oxford. Received April 3, 1867.

On the 15th of March 1858, occurred an annular eclipse of the sun, whose central line of shadow passed near the village of Steeple Aston, a few miles north of Oxford. Ample preparations were made for observing it by residents in Oxford, and they were met on the ground by many persons from a distance; Mr. Lassell being one of the party, there was no lack of telescopic power. The day was unfavourable—cold and cloudy, with some occasional feeble and delusive gleams, scarcely permitting a sight of the progress of the eclipse, which, however, was obvious enough by the growing and diminishing darkness. Under these circumstances I devoted my principal attention to three thermometers, carefully selected and compared beforehand—one mercurial with blackened bulb, another mercurial with clear bulb (these were placed in an open space exposed to the sun); the third, a minimum- spirit thermometer, tint red, was placed in a shaded situation. The observations began at $11^h\ 30^m$ and lasted till $2^h\ 30^m$, thus including the whole period of the eclipse, which began at $11^h\ 35^m$, reached the maximum of obscuration at $0^h\ 54^m$, and ended at $2^h\ 11^m$. The apparent semidiameters of the sun and moon were so nearly equal that the eclipse was almost total $\left(\frac{997}{1000}\right)$. The observations were recorded as follows:—

| Hour. | Thermometer in shade. | Clear thermometer in sun. | Dark thermometer in sun. | Remarks. |
|---|---|---|---|---|
| h m | ° | ° | ° | |
| 11 30 | 49·0 | 51·6 | 58·0 | Gleams. |
| 35 | Beginning of eclipse. | | | |
| 45 | 49·0 | 50·0 | 55·0 | Gleams. |
| 12 0 | 48·5 | 49·5 | 54·5 | |
| 15 | 48·5 | 49·0 | 52·0 | |
| 30 | 48·1 | 48·5 | 50·0 | |
| 45 | 48·1 | 48·5 | 49·2 | |
| 54 | This was the moment of greatest obscuration. | | | |
| 1 0 | 47·5 | 47·5 | 47·5 | Lowest temperature. |
| 15 | 47·5 | 47·5 | 48·0 | |
| 30 | 47·6 | 48·0 | 48·8 | |
| 45 | 48·0 | 49·4 | 51·0 | |
| 2 0 | 48·3 | 49·8 | 51·7 | |
| 11 | End of eclipse. | | | |
| 15 | 49 0 | 50·5 | 53·1 | Rain began. |
| 30 | 48·0 | 49·5 | 51·2 | Rain continued. |
| Mean ... | 48·3 | 49·6 | 51·5 | |
| Max. ... | 49·0 | 51·6 | 58·0 | |
| Min. ... | 47·5 | 47·5 | 47·6 | |
| Range ... | 1·5 | 4·1 | 10·4 | |

During the late partial eclipse of the sun on the 6th of March 1867, observations of the ingress of the moon were favoured at Oxford by brilliant weather; within five minutes after the moment of maximum obscuration $\left(\frac{742}{1000}\right)$ clouds appeared; and from this time till the end of the eclipse they never wholly disappeared, but did not prevent the progress of the moon and the degrees of obscuration from being correctly marked. At the very end it was only just possible to observe the egress by a momentary attenuation of the clouds; the remainder of the day was cold, cloudy, and finally snowy. The observations began at $8^h$ and ended at $10^h\ 50^m$, thus including the whole period of the eclipse, which began at $8^h\ 12^m\ 15^s$, reached the greatest obscuration at $9^h\ 26^m$, and ceased at $10^h\ 45^m\ 8^s$. At the moment of greatest obscuration the light-giving area was reduced to one-third of the solar disk.

The observations comprised—

(1) Temperature in the shade, by the mean of one mercurial and one spirit thermometer very nearly agreeing throughout.

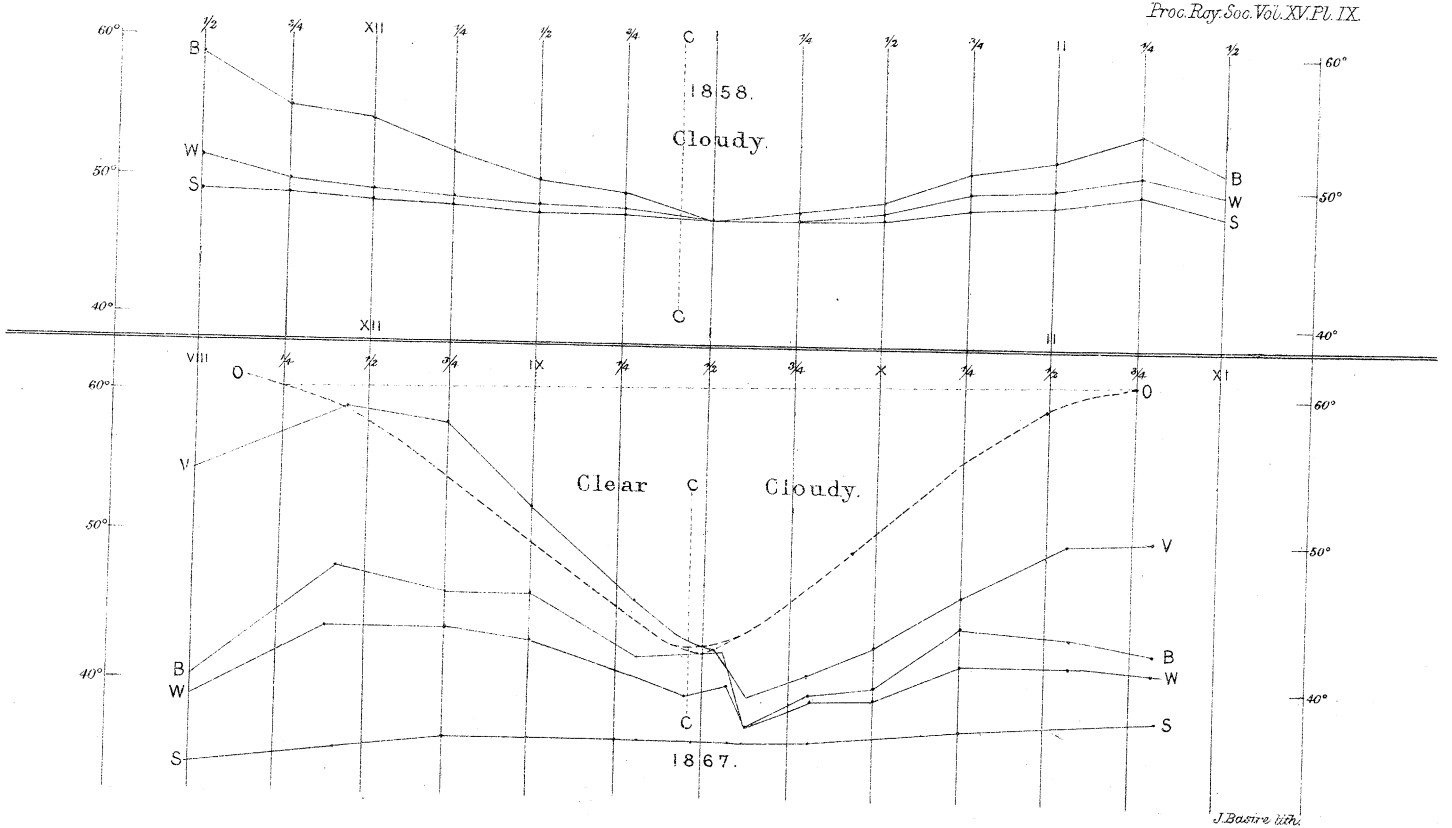
(2) Temperature in the sunlight, by a clear mercurial bulb.

(3) Temperature in the sunlight, by a dark mercurial bulb.

(4) Temperature in the sunlight, by a dark mercurial bulb enclosed in a glass tube exhausted of air.

The observations were recorded at intervals according to convenience ($3^m$ to $20^m$), the shorter intervals being purposely chosen about the time of maximum obscuration. The results are in the following Table:—

| Hour. | Thermometer in shade. | Clear bulb in sun. | Dark bulb in sun. | Dark bulb in glass tube. | Remarks. |
|---|---|---|---|---|---|
| h m | ° | ° | ° | ° | |
| 8 0 | 35·5 | 39·5 | 41·0 | 54·0 | Sky always clear till the middle of the eclipse. |
| 12 | Beginning of eclipse. | | | | |
| 25 | 36·2 | 44·0 | 48·0 | 58·8 | |
| 45 | 36·7 | 44·0 | 46·5 | 57·8 | |
| 9 0 | 36·7 | 43·6 | 46·5 | 52·0 | |
| 18 | 36·7 | 41·5 | 43·0 | 46·5 | |
| 25 | 36·7 | 40·5 | 43·0 | 43·5 | |
| 26 | This was the moment of greatest obscuration. | | | | |
| 32 | 36·7 | 41·5 | 43·2 | 42·9 | Clouds gathered at $9^h\ 30^m$ and continued to the end of the eclipse. |
| 35 | 36·7 | 38·0 | 38·0 | 41·0 | |
| 50 | ..... | 40·0 | 40·5 | 42·0 | |
| 10 0 | ..... | 40·0 | 41·0 | 43·3 | |
| 15 | 37·7 | 42·5 | 44·5 | 46·8 | |
| 35 | ..... | 42·7 | 44·0 | 49·9 | |
| 45 | End of eclipse. | | | | |
| 50 | 38·8 | 42·0 | 43·0 | 50·0 | |
| Mean... | 37·2 | 41·5 | 43·2 | 48·4 | |
| Max. ... | 38·8 | 44·0 | 48·0 | 58·8 | |
| Min. ... | 35·5 | 38·0 | 38·0 | 41·0 | |
| Range .. | 3·3 | 6·0 | 10·0 | 17·8 | |




J. Basire lith.

On considering the columns of figures with attention, it will be perceived that on each occasion all the thermometers in the sunshine sank as the eclipse advanced, so as to reach the greatest depression not at, but after the epoch of greatest obscuration, and from this point rose again as the obscuration diminished, but in neither case arrived at the same elevation as in the beginning of the eclipse. In each case the eclipse began with fair prospects, but was followed by rain or snow.

In the annular (almost total) eclipse three thermometers, two in the sunshine and one in the shade, reached the very same point (47°·5), that being the lowest observed; in the partial eclipse, three thermometers corresponding to the above reached nearly the same point (36°·7, 38°, 38°), the lowest observed. The lowest point was not reached on either occasion by these instruments till some minutes after the moment of greatest obscuration (6 minutes in the annular and 9 minutes in the partial eclipse); while the thermometer enclosed in a tube did not sink below 41° at the same time. The later occurrence of the extreme depression in the partial eclipse was occasioned by the additional cooling influence of the clouds which gathered five minutes after the epoch of greatest obscuration.

By representing the observations in curves with ordinates proportioned to the depressions at the successive epochs, the circumstances which have been referred to are clearly seen,—the convergence of all the lines beyond the time-point of greatest obscuration—the exactitude of this convergence in the uniformly clouded sky of 1858, and the comparative confusion of the lines in the suddenly altered sky of 1867, where the effect of the access of cloud is 1°·9 on the enclosed thermometer, 3°·5 on the clear exposed bulb, and 5°·2 on the black exposed bulb (see Plate IX.).

The effect of the cloud on the instruments employed in the latter half of the eclipse is to reduce the temperatures at the end of the eclipse, as compared with the beginning, more than 8° in the enclosed thermometer, 5° in the dark-bulb exposed, and 2° in the clear-bulb; but in the shaded instruments the effect is contrary, for they gained 2°·6 between beginning and end.

Finally, if the areas of obscuration be calculated for the several epochs of observation (in 1867), and the proportions be represented by a curve adapted to the scale used for temperature, the fact of the postponement of the radiation-effect will appear, as well as the conformity with which the temperatures follow the curve, in the bright half of the eclipse, and fall away from it, but still proportionately, in the clouded half.

## REFERENCE TO PLATE IX.

In the diagram for 1858, the temperatures observed at the several epochs are marked by the crossing of the lines S S for shade, W W for clear bulb, and B B for black bulb. The central time of the eclipse is marked C C.

In that for 1867, similar letters mark similar observations; and, in addition, V V shows the temperatures of the black bulb *in vacuo*, and O O the curve of relative obscuration at the several epochs of observed temperature.